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Brief Communication: A New Correction Procedure for Calibrating Dental Caries Frequency

YILMAZ S. ERDAL[1]* and İZZET DUYAR[2]
[1]*Department of Anthropology, Hacettepe University, 06532 Beytepe, Ankara, Turkey*
[2]*Department of Physical Anthropology, Ankara University 06100 Sıhhiye, Ankara, Turkey*

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ABSTRACT The incisors and canines and the premolars and molars show differential resistance to cariogenic factors. The anterior teeth have a lower caries frequency than the posterior teeth. However, these tooth classes are lost differentially in postmortem stages due to their anatomical structures. This differential postmortem tooth loss distorts proportions between the anterior and posterior tooth classes. The disproportionality can affect the calculation of total caries prevalence. In this paper, we propose a new calibration procedure which removes this disproportionality and call it the proportional correction factor. For this procedure, the caries rates of anterior and posterior teeth are corrected by multiplying the anterior teeth by three-eighths and the posterior teeth by five-eighths. These fractions are derived from the human dental formula which contains three anterior and five posterior teeth by side. The correction factor is more effective if the proportion of anterior to the posterior teeth is extremely distorted. When this procedure is used with the caries correction factor, it provides a useful way to approach to an almost true caries prevalence. Am J Phys Anthropol 108:237–240, 1999.

Oral health indicators have frequently been used to reconstruct the dietary patterns and lifestyles of skeletal populations. Dental caries rates provide anthropologists with valuable information on adaptation to physical and cultural environments. Furthermore, the caries rate is one of the best reflectors of the oral conditions of skeletal populations. Therefore, skeletal biologists have focused on the estimation of the frequencies of dental caries. In this study, our aim is to suggest a new method to obtain a closer estimation of the true caries frequency in skeletal populations than is currently available.

Caries prevalence is calculated in different ways, such as the tooth count method, the individual tooth count (DM index), and the individual counts. Missing teeth are not taken into account in the individual counts approach; thus, a more meaningful caries rate calculation is tooth counting (Hillson, 1990). In archaeological materials, however, the calculation of a real caries rate is difficult because the teeth are usually missing as a result of ante- and postmortem factors.

The dental caries rate is conventionally calculated as follows:

$$\text{Caries index} = \frac{\text{Total number of carious teeth}}{\text{Total number of observed teeth}} \times 100$$

Nevertheless, this calculation does not reflect the real prevalence of dental caries because of ante- and postmortem tooth

*Correspondence to: Yílmaz Selim Erdal, Department of Anthropology, Hacettepe University, 06532 Beytepe, Ankara, Turkey. E-mail: yserdal@eti.cc.hun.edu.tr

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losses. With this calculation, it is impossible to know how many teeth have been lost owing to dental caries. For this reason, some authors offer various counting methods which take antemortem tooth loss by caries into consideration (Hardwick, 1960; Moore and Corbett, 1971; Lukacs, 1992, 1995). These correction procedures have occasionally been used by some anthropologists (e.g., Powell, 1985; Kelley et al., 1991; Lukacs, 1992, 1995, 1996; Erdal 1996; Saunders et al., 1997).

The above-mentioned studies suggest that the corrected caries prevalences are more accurate indicators for skeletal samples. For instance, Lukacs (1992, 1995) calculated caries prevalence as being 6.8% before the correction, and 12.1% after the correction for a Harappan skeletal population. The difference between these two rates is significant. Likewise, the correction of both Hardwick's (1960) calibration and DM index increase the caries prevalence.

On the other hand, postmortem tooth loss is not generally taken into consideration in dental anthropological studies. In a normal adult mouth, there is a ratio between anterior (incisors and canines) and posterior (premolars and molars) teeth. These tooth classes have different characteristics with respect to crown and root morphology. Consequently, in postmortem burial damage, the anterior teeth are more frequently lost than posterior teeth. This is true for disturbed primary and secondary burials and especially for ossuaries. For this reason, the ratio between the anterior and posterior teeth changes with differential tooth loss. Furthermore, the crown morphology of anterior teeth makes them more resistant to cariogenic factors. As a result, the postmortem loss of the anterior teeth (which have fewer carious lesions) will increase the total caries rate. Thus, as Hillson (1990:294) states, "a sample in which caries prevalence was, in reality, higher, but which had better preserved dentition, might come out with a lower caries percentage than another sample, where only cheek teeth were commonly preserved."

In a normal mouth (and in a normal population), the ratio of anterior to posterior teeth is three to five,[1] (i.e., 0.6). But this normal proportion changes according to differential antemortem and postmortem tooth loss. For example, Sledzik and Moore-Jansen (1991) have studied three populations, those of Snake Hill, Civil War soldiers, and Indian Wars soldiers. We have recalculated the anterior to posterior teeth ratio for these groups as 240/359 = 0.67, 77/329 = 0.23, and 53/140 = 0.38, respectively. The differences in the anterior to posterior tooth proportions by cemetery sample illustrate that the changes in the ratio of tooth classes must be taken into consideration when calculating caries prevalence. As stated above, incisors and canines are the most frequently lost teeth, but these teeth do not decay as much as the posterior teeth. In dental anthropological studies, however, the total caries rate is calculated regardless of this fact.

METHODS

In this study, a new method, called the proportional correction factor, is suggested to provide an appropriate ratio between anterior and posterior teeth. In this procedure, the tooth class (i.e., caries rates of anterior and posterior teeth) is corrected according to its own appropriate proportions. That is, the caries rate of anterior teeth is corrected by multiplying by three-eighths,[2] and the caries rate of posterior teeth is corrected by multiplying five-eighths.[3]

The application of the proportional correction method can be demonstrated by using a hypothetical population consisting of 100 individuals. It would theoretically have 3,200 (1,200 anterior and 2,000 posterior) teeth. The ratio of anterior and posterior teeth is 1,200/2,000, or 0.6. We assume that the caries prevalence is 2.0% (24 caries) for the anterior teeth and 16.0% (320 caries) for the posterior teeth. The total caries prevalence for this population is $(24 + 320) \times 100/3{,}200$, or 10.75%.

[1]The ratio of anterior tooth number to posterior tooth number is 3/5 (i.e., 0.6).

[2]The ratio of anterior tooth number to total tooth number for a quadrant of jaws, is 3/8 (i.e., 0.375).

[3]The ratio of posterior tooth number to total tooth number for a quadrant of jaws is 5/8 (i.e., 0.625).

TABLE 1. Caries frequencies calculated by various methods for the İznik (Nicaea) Late Byzantine population

	Uncorrected			Corrected	
	Number of caries	Number of observed teeth	Caries rate (%)	Caries correction factor[1] (%)	Proportional correction (%)
Anterior teeth	44	1,815	2.42	4.39	1.65[2]
Posterior teeth	577	3,894	14.82	21.27	13.29[3]
Total	621	5,709	10.88	16.31	14.94[4]

[1] Lukacs (1995).
[2] $4.39 \times 3/8 = 1.65$.
[3] $21.27 \times 5/8 = 13.29$.
[4] $1.65 + 13.29 = 14.94$.

Suppose that these people have lost 600 of their anterior and 400 of their posterior teeth postmortem. The ratio of anterior to posterior teeth would be 600/1,600, or 0.375. This deviation from 0.6 results from differential losses of anterior and posterior teeth. Such deviations are common in archaeological material. For example, the ratio is 0.47 for İznik, Turkey (Erdal, 1996), 0.38 for American Civil War soldiers, and 0.23 for Indian Wars soldiers (Sledzik and Moore-Jansen, 1991) samples, respectively.

Both postmortem tooth loss and observed teeth should have nearly the same caries frequency, since cariogenic factors affect theoretically both teeth lost postmortem and those preserved. Considering our example, the number of caries for anterior teeth would be found to be 0.02×600 observed anterior teeth, or 12 caries, and for posterior teeth $0.16 \times 1{,}600$ observed posterior teeth, or 256 caries. Consequently, the total caries prevalence would be $(12 + 256) \times 100/2{,}200$, or 12.18%. The caries frequency for observed teeth is higher than the "real" frequency. The reason for this difference is the smaller number of observed anterior teeth following postmortem loss—hence the misrepresentation of the true rate of the anterior and the posterior teeth. The difference between the "real" (10.75%) and the observed (12.18%) frequency is 1.43%, a notable increase in caries frequency. In order to correct this, caries prevalences of the anterior and the posterior teeth are multiplied, respectively, by factors of three-eighths and five-eighths.

For anterior teeth: $2.0\% \times 3/8 = 0.75\%$
For posterior teeth: $16.0\% \times 5/8 = \underline{10.00\%}$
Total caries rate: 10.75%

These values for anterior (0.75) and posterior (10.00) teeth are not caries frequencies for tooth classes but proportional values for the real caries rate for our hypothetical population. Finally, total caries prevalence is calculated as follows: $0.75 + 10.00 = 10.75\%$. One can see that this value is the same as the hypothetical population's caries prevalence.

The proportional correction factor has been applied to an Anatolian skeletal sample, the İznik (Nicaea) population dating back to the Late Byzantine (AD thirteenth century) period (Erdal, 1996).

RESULTS AND DISCUSSION

Table 1 shows the caries frequency in the İznik sample determined by different methods. The sample of 5,709 teeth consisted of 1,815 anterior and 3,894 posterior teeth (Erdal, 1996). The caries frequencies for the anterior and the posterior teeth are 2.42% and 14.82%, respectively. The total uncorrected caries rate is 10.88%. As shown in Table 1, anterior teeth are more frequently lost than posterior teeth. The ratio between tooth classes is 0.47, which is less than in the normal proportion (0.6). By using the caries correction factor (Lukacs 1995), Erdal (1996) recalculated the caries frequency in order to generate a figure closer to the true caries rate. After this correction, the caries frequency for the İznik population was found to be 16.31%. This value does not reflect the real caries rate for this sample, however, since the calculation does not take into account the proportion of tooth classes. When the proportional correction is applied to the İznik sample, the frequency decreases absolutely to 14.94%. This calculation procedure is closer to the real caries frequency, taking

ante- and postmortem tooth losses into consideration. With respect to Sledzik and Moore-Jansen's study (1991), the caries rates for Snake Hill, Civil War and Indian Wars populations were calculated by using proportional correction as 12.18%, 19.16% and 12.57%, respectively, though the authors reported the caries rates for those populations as 11.9%, 21.7%, and 14.0%, respectively. The percentage differences between these estimates are +0.28 for Snake Hill, –2.51 for the Civil War sample, and –1.43 for the Indian Wars sample. It is worth noting that the proportional correction does not only provide a decrease in caries frequency but also provides an increase in that frequency when the proportion between the anterior and posterior teeth exceeds 0.6.

In summary, in order to calculate true caries frequency, researchers should pay closer attention to antemortem tooth loss. After the caries correction factor (Lukacs 1995), the proportional correction should be used for the real caries frequency when the appropriate proportion is distorted. This calibration can also be used for children's total caries rate. In addition to this calibration, different proportional coefficients (three-fifths for anterior and two-fifths for posterior teeth) should be applied for deciduous teeth.

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